

SPECIFICATION

TITLE

**"METHOD FOR THE PRODUCTION OF A CORRECTED X-RAY
IMAGE DATA SET"**

5

BACKGROUND OF THE INVENTION

Field of the Invention

10 The invention concerns a method for correction of the pixels of an x-ray
image data set.

Description of the Prior Art

15 X-ray apparatuses ~~comprise~~ have a storage or image plate, for
example, as an x-ray detector. ~~It~~ This can thereby ~~respectively~~ be a substrate
on which an x-ray ~~memory~~ storage luminophore layer is deposited. Such an
20 image plate is typically arranged in a cassette. The x-ray radiation attenuated
upon penetration through the examination subject ~~impacts on~~ interacts with
the storage film as an x-ray intensity distribution and is absorbed there
thereby. Electrons in luminophore crystals are thereby ~~transferred~~ converted
into an excited, meta-stable state. The electrons located in an excited, meta-
25 stable state are excited again ~~with~~ by photo-simulation and consequently
revert to their ground state. Light proportional to the x-ray intensity
distribution is thereby emitted and detected with a readout device that is
suitable and known to ~~the average man~~ those skilled in the art from, for
example, Schulz, Forschungsbericht Röntgenstrahlung 2001 (173), pages
30 1137 – 1146. A computer downstream from the readout device calculates an
x-ray image data set from the read data.

The sensitivity of the storage film can be inhomogeneous, such that
given exposure of the image plate with a homogeneous x-ray intensity
distribution the corresponding x-ray image exhibits different grey values. In
30 order to compensate the inhomogeneous sensitivity of the storage film, the
individual pixels of the x-ray image data set can ~~therefore~~ thus be corrected

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(and in particular normalized) with respective correction values associated with one of the individual pixels. The individual correction values can, ~~for example,~~ be experimentally determined, for example, for an individual image plate before its delivery and be stored once on a data storage memory of the
5 readout device.

Given specific materials for the storage film, the sensitivity with the accumulated x-ray radiation to which the storage film is exposed can ~~moreover~~ change. Such materials are, for example, doped alkali halogenide, for example KBr, RbI, RbBr, CSBr doped with IN, Ga, TL and/or Eu. Since
10 the x-ray radiation is attenuated by the examination subject, the applied x-ray doses of the individual sub-regions of the storage film differ. For example, the boundary regions of the storage film are thus normally exposed to a higher x-ray dose than regions near the middle of the storage film. In general, the accumulated x-ray doses of the individual sub-regions of the storage film thus
15 differ. The sensitivities of the sub-regions of the storage film consequently also change differently with time, i.e. with the number of x-ray image data sets produced.

SUMMARY OF THE INVENTION

~~It is therefore the~~ An object of the invention is to ~~specify~~ provide a
20 method in which the changing sensitivities of the sub-regions of the storage film due to the accumulated x-ray doses of the storage film are accounted for in the correction.

~~The~~ This object is achieved ~~via~~ in accordance with the invention by a method for correcting the pixels of an x-ray image data set, ~~comprising~~ having
25 the following method steps:

- acquisition of an x-ray exposure of an examination subject with an x-ray apparatus that comprises a storage film as an x-ray detector, which storage film comprises a memory luminophore layer, ~~whereby~~ the sensitivity of the memory luminophore layer

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changes changing with the accumulated x-ray dose ~~that to~~ which the memory luminophore layer is exposed to,

- readout of the storage film with a readout device after the x-ray exposure,

5 - generation, from the data determined via the readout process, of an x-ray image data set associated with the x-ray exposure, and

- correction of each pixel ~~image-point~~ of the x-ray image data set with a correction value associated with the corresponding pixel of the x-ray exposure, whereby with each individual correction value is being adapted based on the accumulated x-ray dose ~~that to which~~ the part of the storage film ~~that is associated~~ containing with the corresponding pixel of the x-ray image data set was exposed to before the current x-ray exposure.

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Since the sensitivity of the storage film changes differently with the ~~respectively-accumulated~~ x-ray dose, the correction value in accordance with the invention is ~~thus inventively~~ adapted for each pixel of the x-ray image data set due to the accumulated x-ray dose to which sub-regions of the storage film were exposed. The change of the sensitivity of a specific memory luminophore can ~~thereby~~ be experimentally determined from measurements.

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20 For a type of storage film or, ~~respectively, memory~~ storage luminophore, the function $EB_{i,j}^m = f(D_{i,j}^m)$, thus the correction value for the m-th x-ray exposure, can thus be determined as a function of the accumulated x-ray dose $D_{i,j}^m$ in order to then correspondingly adapt the individual correction values. More or less complex functions (such as, for example, overlapping e-functions) result

25 depending on the storage film material.

According to a variant of the invention, the m-th x-ray image data set (thus the current x-ray image data set to be generated) is corrected according to the following relation:

$$B_{i,j}^m = a * RB_{i,j}^m / EB_{i,j}^m.$$

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a is thereby a first scaling factor, $RB_{i,j}^m$ is the signal of the pixel i, j of the m-th x-ray image data set, $EB_{i,j}^m$ is the correction value for the pixel i, j of the m-th x-ray image data set and $B_{i,j}^m$ is the signal of the pixel i, j of the m-th corrected x-ray image data set. This type of correction is a normalization of the x-ray image data set.

In some cases such as, for example, given for CsBr:Eu as a storage film material, the change of the sensitivity given typically applied x-ray doses is linear with the accumulated x-ray dose. According to a preferred embodiment of the inventive method, the accumulated x-ray dose $D_{i,j}^m$ for the sub-region of the storage film that is associated with the pixel i, j is therefore determined according to the following relation for the m-th x-ray image data set:

$$D_{i,j}^m = \sum_{n=1}^{m-1} b * B_{i,j}^n ,$$

whereby wherein b is a second scaling factor.

According to a preferred variant of the inventive method, the correction value $EB_{i,j}^m$ for the pixel i, j of the m-th x-ray image data set can thus be determined according to the following relation:

$$EB_{i,j}^m = EB_{i,j}^0 - s * \left(\sum_{n=1}^{m-1} b * B_{i,j}^n \right) ,$$

whereby wherein s is a constant and $EB_{i,j}^0$ is the correction value that is associated with the storage film without applied x-ray dose. The correction values can also be smoothed by means of low-pass filtering for noise suppression. Furthermore, since the applied x-ray dose per exposure can be relatively small, it can be sufficient ~~that~~ if the correction values are not updated given each exposure. Under the circumstances it can thus be sufficient to implement an updating after 10, 100 or even after 1000 exposures.

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~~An exemplary embodiment is exemplarily shown in detail in accompanying schematic Figures. Thereby shown are:~~

~~Fig. 1 an x-ray apparatus with a memory plate,~~

~~Fig. 2 a readout device for the memory plate shown in Fig. 1 and~~

5 ~~Fig. 3 a graphical representation of the change of the sensitivity of the memory plate shown in Fig. 1 as a function of the accumulated x-ray dose.~~

DESCRIPTION OF THE DRAWINGS

Figure 1 schematically illustrates an x-ray apparatus with a storage plate.

10 Figure 2 schematically illustrates a readout device for the storage plate of Figure 1.

Figure 3 graphically illustrates the change in the sensitivity of the storage plate of Figure 1 as a function of the accumulated x-ray dose.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

15 ~~In a schematic view, Fig. 1 shows an x-ray apparatus with a memory storage plate 1 comprising embodying a storage film. An x-ray beam 3 whose edge rays are shown dashed in Fig. 1, which x-ray beam 3 emanates from the x-ray source 2 of the x-ray apparatus, and is attenuated upon penetration through an examination subject (a patient 4 in the case of the present exemplary embodiment) and impinges on strikes the memory plate 1 as an x-ray intensity distribution. The x-ray intensity distribution is absorbed by the storage film which, in the case of the present exemplary embodiment, comprises has an x-ray luminophore layer made up composed of CsBr:Eu.~~

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25 After the x-ray exposure, the memory storage plate 1 is evaluated with a readout device 20 schematically shown in Fig. 2 and, for example, known from Schulz, Forschungsbericht Röntgenstrahlung 2001 (173), pages 1137 – 1146. An incident surface of the memory plate 1 is homogeneously exposed with light by means of the readout device 20. The light consequently emitted by the memory storage plate 1 is detected and transduced into a matrix-

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shaped x-ray image data set by means of a data processing device 21 of the readout device 20. In order to compensate the sensitivities of different sub-regions of the storage film of the ~~memory~~ storage plate 1 due to different accumulated x-ray doses, in the case of the ~~present~~ exemplary embodiment
5 the individual pixels of the x-ray image data set are corrected according to the following:

$$B_{i,j}^m = a * RB_{i,j}^m / EB_{i,j}^m,$$

~~whereby~~ wherein ~~a is thereby~~ a scaling factor, $RB_{i,j}^m$ is the signal of the pixel i, j of the x-ray image data set, $EB_{i,j}^m$ is a correction value for the pixel i, j of the
10 x-ray image data set and $B_{i,j}^m$ is the signal of the pixel i, j of the corrected x-ray image data set. The index m ~~thereby~~ means that it is the m-th x-ray image data set or, ~~respectively~~, that (m-1) x-ray exposures were already produced with the memory plate 1 before the current x-ray exposure. In the ~~case of the~~ ~~present~~ exemplary embodiment, the x-ray image associated with the
15 corrected x-ray image data set ~~comprising~~ composed of the individual pixels $B_{i,j}^m$ can be ~~considered with~~ viewed at a monitor 22 connected with the data processing device 21.

In the ~~case of the present~~ exemplary embodiment, the x-ray ~~memory~~ storage luminophore layer of the memory plate 1 changes its sensitivity
20 linearly with the accumulated x-ray dose $D_{i,j}^m$ and in fact as is graphically shown in Fig. 3. In the case of the preferred exemplary embodiment, the individual correction values $EB_{i,j}^m$ associated with the corresponding pixels $RB_{i,j}^m$ of the x-ray image data set are therefore calculated according to the following relation:

$$EB_{i,j}^m = EB_{i,j}^0 - s * \left(\sum_{n=1}^{m-1} b * B_{i,j}^n \right).$$

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b and *s* are ~~thereby~~ constants, whereby *s* is being the slope of the correction value as a function of the accumulated x-ray dose. $EB_{i,j}^0$ is the correction value of the x-ray memory luminophore layer without applied x-ray dose or, respectively, at a specific point in time at which the correction value was, for example, experimentally determined.

Although modifications and changes may be suggested by those skilled in the art, it is the invention of the inventor to embody within the patent warranted heron all changes and modifications as reasonably and properly come within the scope of his contribution to the art.

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Patent claims

I CLAIM AS MY INVENTION:

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